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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Cooper	Docket No:	TI-23516
Serial No:	08/985,380	Examiner:	A. Sniezek
Filed:	12/04/97	Art Unit:	2753

For: METHOD AND APPARATUS FOR CONTROLLING A VOICE COIL MOTOR OF A HARD DISK DRIVE

APPEAL BRIEF PURSUANT TO 1.192(c)

Assistant Commissioner for Patents
Washington, DC 20231

Dear Sir:

The following Appeal Brief is respectfully submitted in triplicate and in connection with the above identified application in response to the final rejection mailed August 7, 2001 and the Advisory Action mailed October 19, 2001.

REAL PARTY IN INTEREST

The real party in interest is Texas Instruments Incorporated.

RELATED APPEALS AND INTERFERENCES

Appellants legal representative knows of no appeals or interferences which will be directly affected, or have a bearing on the Board's decision.

STATUS OF THE CLAIMS

Claims 1-21 were originally filed with Claims 1-10, 19 and 20 standing withdrawn due to a restriction requirement. Claim 21 was withdrawn as result of a claim amendment. Thus, the subject matter of the instant appeal is the final rejection of Claims 11-18.

STATUS OF AMENDMENTS

The application was filed with Claims 1-21. By virtue of a response filed on November 4, 1999, Appellants withdrew Claims 1-10, 19 and 20 from consideration. A response to the final office action was filed on October 5, 2001, amending no claims. The Examiner indicated that the request had been considered but did not place the application in condition for allowance. Applicants presume that the response was entered.

SUMMARY OF THE INVENTION

Figure 1 illustrates a block diagram of the hard disk drive device 11 of the present invention. The hard disk drive 11 includes a head/disk assembly 10 controlled by a control loop or control section 30. The control section 30 includes a digital-to-analog converter circuit 40 and a digital signal processor 36. Additionally, the head/disk assembly 10 includes a magnetic disk stack 12 fixedly supported on a spindle 14, with the spindle 14 being rotationally driven by a spindle motor.

The head/disk assembly 10 also includes an actuator which is a voice coil motor 16, and a plurality of suspension arms 18. A plurality of read/write heads 20 are provided on the arms 18 at the ends thereof remote from the axle 19. Typically, each side of a disk has a plurality of concentric tracks with each track being divided into a plurality of arcuate sectors. Each sector of each track generally includes a servo wedge. The servo wedge provides position information, which is read by the corresponding read/write head 20 and then provided to the control section 30 as an analog servo wedge signal shown at 21.

The voice coil motor 16 is controlled by the control section 30. The control section 30 includes a position error signal channel 32, an analog-to-digital converter circuit 34, a digital signal processor 36, a memory 38, a digital-to-analog converter circuit 40, and power amplifier 42.

Figure 2 is a block diagram of the system of Figure 1, showing the control approach implemented by the DSP 36 of Figure 1. In Figure 2, reference numeral 58 designates a block that represents the physical plant of the hard disk drive 11, which includes the power amplifier 42, the position error signal channel 32, and all of the components of the head/disk assembly 10. The output of the physical plant 58 is the analog positioning error signal 43 of Figure 1, which is supplied to the analog-to-digital converter 34, which in turn outputs the digital positioning error signal 45.

The digital-to-analog converter circuit 40 includes a first digital-to-analog converter 54 which outputs a first analog positioning signal component 59, a second digital-to-analog converter circuit 56 which outputs a second analog positioning signal component 61, and a summing junction 57 which adds the analog signal components 59 and 61. The summing junction 57 adds the signal components 59 and 61 in a manner so that the signal components 61 has a significantly greater weight in the analog positioning signal 48 than in the signal component 59.

The control loop 50 utilizes a model reference control technique which is represented by blocks 68 and 70. The block 68 is a model reference which is a model of the control characteristics of the physical plant 58. The model reference 68 accepts as an input a feedforward control signal 72, and produces at its output a model control signal 74. The model control signal 74 represents the theoretical or expected response of the actual physical plant 58 if the feedforward control signal 72 were applied to the actual plant 58.

The block 70 is a model reference control which is responsive to the model control signal 74 and an input signal 76 identifying a desired or target track. The model reference control 70 generates the feedforward control signal 72 so as to control the model reference

68 in a manner which, in the actual physical plant 58, would cause a read/write head 20 to move to and then stay in radial alignment with a target track identified by the input signal 76.

The control loop 50 further includes a state estimator 60, which is responsive to the digital positioning error signal 45 from the analog-to-digital converter 34, as well as the digital positioning signal 78 from a summing junction 66. The state estimator 60 outputs a state estimation signal 80 which is an estimated state vector of the physical plant 58, including a position, velocity, and acceleration of the arms 18 supporting the read/write heads 20.

The control loop 50 includes a junction 62 which subtracts the state estimation signal 80 representing the estimated state vector from the model control signal 74 representing the model control vector, and outputs the vector difference on line 82 as the state error signal representing a state error vector. The junction 62 includes three junctions which respectively determine the difference between the position information in signals 74 and 80, the velocity information in signals 74 and 80, and the acceleration information in signals 74 and 80, and which output respective difference signals at 82 as state error information representing a state error vector.

The feedforward control signal 72, $u_{ff}(k)$ and the correction control signal 84 may be represented by the term $u_c(k)$, where "k" represents a sample number. The "u" is a control variable which can be viewed as either representing voltage or current. The feedforward control signal 72 and the correction control signal 84 are respectively coupled to the inputs of the DACs 56 and 54 together make up the digital positioning information shown at 48 in Figure 1.

The control system in Figure 3 also includes a model reference control 104, a model reference 105, a state estimator 106, and a control law 107, which respectively correspond functionally to the components 70, 68, 60, and 64 in Figure 2.

The model reference control 104 has a junction 114 that subtracts a model reference position value 115 produced by the model reference 105 from the input 116 which is a position value representing a target track. The difference generated by the junction 114 is supplied to a control block 118, which determines a desired velocity Vd. In particular, the desired velocity Vd is the square root of a quantity which is the difference from junction 114 or a quantity which is a difference from junction 115 multiplied by a gain 2A, where A is the desired acceleration rate. The desired velocity Vd from block 118 is supplied to a junction 119. The junction 119 subtracts from the desired velocity Vd a model reference velocity value 122 received from the model reference 105. The output of the junction 119 subtracts from the desired velocity Vd and model reference velocity value 122 received from the model reference 105. The output of the junction 119 goes to a lead/lag network 12A, which output is a feedforward control value 123, which is supplied to the DAC 56 and to the summing junction 66.

The model reference 105 includes a gain element 126, which receives as an input the feedforward control value 123 from the model reference control 104. Gain element 126 applies to the feedforward control value a gain $K_T r/J$, where K_T is a torque constant of the voice coil motor 16 in the physical plant 58, r is the radial distance along the arm 18 from the axle 19 to the read/write head 20, and J is the inertia associated with the voice coil motor 16.

ISSUES

The two issues on appeal is first whether or not Claims 11-13 and 16-18 are unpatentable under 35 U.S.C. §103 over Suzuki in view in Moon and second whether or not Claims 14 and 15 are unpatentable under 35 U.S.C. §103 over Suzuki in view of Moon and Official Notice.

GROUPING OF THE CLAIMS

Claim 11 is independently patentable.

ARGUMENTS

It is respectfully submitted that Suzuki does not disclose or suggest the presently claimed invention including an expected response including a model reference control technique after an initialization of the hard disk drive and based on an expected response of an actuator to a feed forward control signal.

Applicants agree with the Examiner that such a feature is not taught by Suzuki.

It is respectfully submitted that Moon does not disclose or suggest the presently claimed invention including a digital signal processor utilizing a model reference control technique after an initialization of the hard disk drive system and based on a expected response of the actuator to a feed forward control signal.

The Honorable Board's attention is directed to col. 14, lines 50-55 of Moon. Here, Moon discloses that the necessary value of C_{ffwd} may be determined by manual characterization of the disk drive or by automated self-characterization during disk drive initialization.

In contrast, the presently claimed invention performs this feature after the initialization.

Official Notice does not cure these defects.

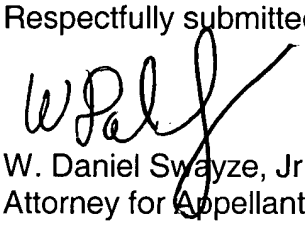
It is respectfully submitted that Claims 11-18 define over the applied art.

CONCLUSION

For the foregoing reasons, Appellants respectfully submit that the Examiner's final rejection of Claims 11-18 under 35 U.S.C. § 103 is not properly founded in law, and it is respectfully requested that the Board of Patent Appeals and Interferences so find and reverse the Examiner's rejections.

To the extent necessary, the Appellants petition for an Extension of Time under 37 CFR 1.136. Please charge any fees in connection with the filing of this paper, including extension of time fees, to the deposit account of Texas Instruments Incorporated, Account No. 20-0668. **This form is submitted in triplicate.**

Respectfully submitted,



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APPENDIX

11. A control system for controlling a hard disk drive having a rotatably supported disk, a read/write head which is movable relative to the disk and which outputs an analog servo wedge signal read from the disk, and an actuator operable to urge movement of the read/write head relative to the disk in response to an analog positioning signal, said control system comprising:

a position-error-signal channel operable to generate an analog position error signal in response to the analog servo wedge signal;

an analog-to-digital converter circuit operable to convert the analog position error signal to a digital position error signal;

a digital signal processor operable to generate digital positioning information as a function of the digital position error signal, said digital signal processor utilizing a model reference control technique a after an initialization of said hard disk drive and based on an expected response of the actuator to a feed forward control signal of said hard disk drive in generating the digital positioning information; and

a digital-to-analog converter operable to convert the digital positioning information into the analog positioning signal.

12. A control system according to Claim 11, wherein the digital positioning information generated by said digital signal processor includes:

a digital first positioning signal component; and

a digital second positioning signal component; and

wherein said digital-to-analog converter includes:

a first digital-to-analog converter operable to convert the digital first positioning signal component into an analog first positioning signal component;

a second digital-to-analog converter operable to convert the digital second positioning signal component into an analog second positioning signal component; and

a summing arrangement operable to generate the analog positioning signal by combining the analog first positioning signal component and the analog second positioning signal component in a manner giving the analog first positioning signal component greater weight than the analog second positioning signal component.

13. A control system according to Claim 11, further comprising:

a power amplifier operable to amplify the analog positioning signal to generate an amplified analog positioning signal which is applied to the actuator.

14. A control system according to Claim 11, wherein said digital-to-analog converter and said digital signal processor are fabricated in a single piece of semiconductor material.

15. A control system according to Claim 11, wherein said digital-to-analog converter circuit and said digital signal processor are fabricated in a single piece of semiconductor material which is silicon.

16. A control system according to Claim 11, wherein said digital signal processor is further operable to utilize a state estimator technique in generating the digital positioning signal.

17. A control system according to Claim 11, wherein said digital signal processor is further operable to utilize a control law in generating the digital positioning signal.

18. A control system according to Claim 11, wherein the digital positioning information generated by said digital signal processor includes:

a digital first positioning signal component; and

a digital second positioning signal component;

said digital signal processor being operable to utilize said model reference control technique to generate the digital first positioning signal component; and

said digital signal processor being operable to utilize a state estimator technique to generate a state estimate signal in response to the digital positioning signal and the digital position error signal, and being operable to utilize a control law technique to generate the digital second positioning signal component in response to the state estimate signal and said model reference control technique;

said digital-to-analog converter including:

a first digital-to-analog converter operable to convert the digital first positioning signal component into an analog first positioning signal component;

a second digital-to-analog converter operable to convert the digital second positioning signal component into an analog second positioning signal component; and

a summing arrangement operable to generate the analog positioning signal by combining the analog first positioning signal component and the analog second positioning signal component in a manner giving the analog first positioning signal component greater weight than the analog second positioning signal component.

21. (Amended) A method according to Claim ~~18~~ 19 wherein said step of generating the digital third control signal includes the steps of:

generating a digital positioning signal by adding the digital first control signal and the digital third control signal in a manner giving the digital first control signal greater weight than the digital third control signal;

generating in response to the digital positioning signal and the digital position error signal a state estimation signal representing an estimated state of the actuator;

generating a state error signal by subtracting the state estimation signal from the second control signal; and

generating in response to the state error signal a correction control signal which is the digital third control signal.